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LISTS OF SPECIES

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First comprehensive list of the coral reef fishes of Tunku Abdul Rahman Park, Sabah, Malaysia (Borneo)

Ditch Townsend

4 Park Cottages, Chawleigh, Devon, EX18 7LB, United Kingdom
E-mail: ditchtow@gmail.com

Abstract: A 573 species-long checklist of the fishes in this 50 km² tropical marine park was created predominantly by combining an unpublished scientific survey from 1992 with a hobbyist's large photograph collection from between 2006 and 2009. Of the Indo-Pacific region's coral reef-associated fish species, 15.2% are found here. Drawn from 83 families, the most speciose are Pomacentridae (71), Gobiidae (68) and Labridae (55). A regression formula using the Coral reef Fish Diversity Index (CFDI) for species seen in 1992 suggests the park hosts 464 species, compared with the CFDI-based estimate of 495 based only on data collected between 2006 and 2009, and 596 for the combined Index. With only 62% of the Index's species seen both in the earlier and later lists, the utility of the CFDI is questionable at a site or over a time-span like this.

Key words: coral reef; fishes; Tunku Abdul Rahman Park; marine park; species richness; CFDI

INTRODUCTION

Citizen science can be valuable, not least surveys in marine environments (Holt et al. 2013). Matching such surveys with unpublished scientific field survey notes can be an opportunity for fruitful collaboration. Such a collaboration began in part with an attempt to identify the cardinalfish in Figure 1; one of the largest, most colourful of the genus *Apogon*. I contacted Gerald Allen who identified it as a new species in the study area in 1992 (subsequently identified as a synonym of an elsewhere rarely encountered fish), and he alerted me to the existence of his unpublished field notes.

On the southeast margin of the South China Sea, the outer limit of Tunku Abdul Rahman national marine park (TARP) is 5 km from the shore of Kota Kinabalu, the main city of Sabah on the west coast of this northernmost state of Malaysian Borneo. Starting 2 km from the city's marina, it covers nearly 50 km² including four small islands and most of one larger island. Heavily affected by runoff and debris from the city and local rivers, frequently damaged by ghost gill nets and illicit fishing, and despite being a typically silty inshore coral reef affected by significant seasonal algal blooms, the coral reefs remain resilient. Most SCUBA diving tourism in Sabah is directed to Sipadan on its east coast, in the Sulu Sea. TARP is predominantly a snorkelling destination for package tourists, predominantly from peninsular Malaysia and northeast Asia — nearly 400,000 in 2012 alone, and nearly 10 times more than visit Sipadan (Sabah Parks 2014). Six dive operators also offer SCUBA diving training and day trips.

Without a publicly acknowledged checklist of TARP's fishes, it remains susceptible to inadequately monitored ecological damage from city pollution, tourism growth, and infrastructure development (currently shelved plans exist to provide Gaya island with a coastal road). More positively, TARP is an accessible location to consider research into examples of coral reef resilience in support

Figure 1. *Apogon griffini* – a rarity outside Tunku Abdul Rahman Park and characteristic of the park's hidden splendour.

of global contingency planning for reefs threatened by climate change, ocean acidification, and infrastructure development.

TARP's underwater habitats reach a maximum depth of 30m, without significant drop-offs, or upwelling currents, and being generally shallower nearer the coast. Each island has fringing coral, including large beds of soft corals, sloping gently horizontally from around 15–20 m on the seaward side of the outer islands, before ending 200 m away (at most) in fine sandy margins near 30 m. Silt covers the areas between islands and the mainland, with occasional interspersed coral patches. The largest island (Gaya) hosts several small mangrove areas. Several island sandy beaches have mini-lagoons fringed by coral, except in two places where steep sand banks drop down to the silt bottom at about 20 m. Off the coastal side of Sapi Island, there is one small boat wreck at around 15 m and scattered small tyre and concrete artificial reefs from there up to around 5 m. Sea grass areas around Gaya Island are patchy and limited. A number of wooden jetties attract mixed and occasionally pelagic shoals where fish feeding is allowed by tourists, and provide large shaded shallow sandy areas. Visibility varies from 5–30 m throughout the year, generally being around 15 m. Water temperatures vary little from 26–29°C, but a noticeably colder (24–26°C) thermocline can appear at 10–20 m in December to March.

Bellwood (1998) points out that the term "reef fishes" defies non-tautological definition; with him I have defined coral reef fishes in TARP as "those individuals that live on coral reefs" (or associate with them). Unless otherwise noted, I mean coral reefs when I use the term reef.

MATERIALS AND METHODS

Data collection

In 1992, fish surveys in TARP were conducted by Gerald Allen, with permission to undertake collections granted by the Sabah Parks department. Over the course of 10 days, in multiple sites and depths, he undertook visual transects, rotenone stations, and spearing. His checklist from the time has been passed to me but has neither been published, nor incorporated in any publication, and is incorporated here with his agreement.

Between April 2006 and July 2009, I spent over 95 hours photographing fishes: 15½ hours of this was spent snorkelling, and the remainder SCUBA diving (over 41 days and 2 nights). I visited 31 underwater sites, and every known habitat type in the park.

A number of diving operators in TARP occasionally alerted me to photos they had put online of fishes in TARP. Their web sites were reviewed immediately prior to writing this paper.

Figure 2. *Ecsenius trilineatus* – or is it? Blenny experts have suggested it may be something new.

Data analysis

Given Gerald Allen's expertise and 25 year's field experience identifying Indo-Pacific fishes prior to 1992, all of his asserted identifications have been accepted at face value, noting his comment: "It is emphasized that only species identifications for which I was absolutely positive were added to the list." He also collected 145 voucher specimens, some of which have added names not on the original list pending lab identification when it was drafted (14 of them were inadvertently dated 1991). They are deposited in the Western Australian Museum in Perth, referred to in the list below as: [1992 – WAM (with catalogue number)]. Also included in the list below are two species which have only been identified to genus level but are clearly not another species in the list.

I have nearly 2,700 photos of fishes I took in TARP. Each one has been reviewed using multiple online and published sources (mainly Allen and Erdmann 2012). Advice for difficult examples has been sought from specialists (see Acknowledgements). Vic Springer and Jeff Williams at the Smithsonian Institute incidentally noted that one Blenny (Figure 2) may well represent an undescribed species encountered by others in the Philippines. A set of 1,016 photos which includes all species seen by me (but not necessarily only me) has been permanently deposited on-line (http://dx.doi.org/10.6084/m9.figshare.1551940). Two additional species were not photographed but were identified by me, although they have been excluded from the list for want of photographic evidence: *Centropyge vrolikii* (Bleeker, 1853) and *Rastrelliger kanagurta* (Cuvier, 1816).

Nine species have also been identified (one of them only to genus) in publicly available photos from three dive operators in TARP between 2006 and 2012. Their

internet links are given in the list (but if broken, I vouched for their identification at the time of writing). Included amongst the nine is one species which has only been identified to genus level but is clearly not another species in the list.

RESULTS

Counts

Evidence exists for the presence of 573 species of fishes in TARP between 1992 and 2012. Of these, 372 were seen by Allen (123 or 21.5% of the 573 uniquely by him), 441 photographed by me (192 or 33.5% of the 573 uniquely), and nine (1.6%) only by dive operators.

Eighty-three families are found in TARP 10% of which represent 57% (324) of its known species. These eight families (species numbers in brackets) are Pomacentridae (71), Gobiidae (68), Labridae (55), Apogonidae (51), Blenniidae (24), Scaridae (22), Chaetodontidae (20), and Serranidae (13).

Estimates

Allen (1998) first proposed a method for calculating estimated reef fish species richness based on what he has termed the Coral reef Fish Diversity Index (CFDI; see also Donnelly et al. 2003). It uses a regression formula from counts of observed species in six indicator families (Acanthuridae, Chaetodontidae, Labridae, Pomacanthidae, Pomacentridae, and Scaridae). Following identification of uncertain voucher specimens and additions from the voucher collection which were mistakenly missing from Allen's original list, his CFDI of indicator species in TARP in 1992 is 143, and his regression estimate (3.39 × CFDI) – 20.595 for areas under 2,000 km^2) is 464 species. This suggests he had identified 80% (372) of the probable total. My own CFDI for TARP based on three years of continuous data collection is 152, and the predicted species richness is 495 (apparently 89% complete). Combining all the data now available for TARP, the CFDI stands at 182, the predicted species richness is 596, and the actual list is apparently 96% complete.

Checklist

Allowing for new range information (Allen's *Ostorhinchus properuptus* has been reallocated to *O. wassinki*, his *Cetoscarus bicolor* to *C. ocellatus*, his *Parapercis hexophtalma* to *P. pacifica*, his *Salarias sexfilum* to *S. sinuosus*, his *Amblyeleotris fasciatus* to *A. wheeleri*, his *Amblyeleotris bynoensis* to *A. stenophthalmus*), and nomenclature and spelling changes since Allen's 1992 trip, the following list indicates the earliest and latest years of observation (and by implication the observer). The results are ordered by family according to van der Laan (2014), and then named alphabetically by genus and species according to Eschmeyer (2015). The number of species in each family is given in parentheses:

Rhincodontidae (1)

Rhincodon typus Smith, 1828: [(Borneo Dream 2012)]

Hemiscylliidae (1)

Chiloscyllium punctatum Müller & Henle, 1838: [(Swann 2009)]

Stegostomatidae (1)

Stegostoma fasciatum (Hermann, 1783): [1992]

Scyliorhinidae (1)

Atelomycterus marmoratus (Anonymous [Bennett], 1830): [1992, 2006]

Carcharhinidae (1)

Carcharhinus melanopterus (Quoy & Gaimard, 1824): [(Hammond 2008)]

Dasyatidae (3)

Neotrygon kuhlii (Müller & Henle, 1841): [1992, 2008]
Himantura fai Jordan & Seale, 1906: [2006, 2008]
Taeniura lymma (Forsskål, 1775): [1992, 2008]

Moringuidae (1)

Moringua microchir Bleeker, 1853: [1992 – WAM 30397.038]

Muraenidae (9)

Echidna nebulosa (Ahl, 1789): [2008]
Enchelycore bayeri (Schultz, 1953): [1992]
Gymnothorax albimarginatus (Temminck & Schlegel, 1846): [1992]
Gymnothorax isingteena (Richardson, 1845): [1992, 2007]
Gymnothorax javanicus (Bleeker, 1859): [2007, 2008]
Gymnothorax thrysoideus (Richardson, 1845): [2006, 2007]
Gymnothorax zonipectis Seale, 1906: [2009]
Rhinomuraena quaesita Garman, 1888: [(Swann and Swann 2008)]
Uropterygius concolor Rüppell, 1838: [2007]

Ophichthidae (4)

Apterichtus sp.: [1992 – WAM 30397.024]
Ophichthus altipennis (Kaup, 1856): [2008, 2009]
Ophichthus rutidoderma (Bleeker, 1853): [1992]
Scolecenchelys laticaudata (Ogilby, 1897): [1992]

Congridae (1)

Heteroconger perissodon Böhlke & Randall, 1981: [2008]

Clupeidae (1)

Spratelloides gracilis (Temminck & Schlegel, 1846): [1992 – WAM 30401.001]

Engraulidae (1)

Thrissina baelama (Forsskål, 1775): [1992 – WAM 30399.005]

Plotosidae (2)

Paraplotosus albilabris (Valenciennes, 1840): [1992, 2008]
Plotosus lineatus (Thunberg, 1787): [1992, 2009]

Synodontidae (4)

Synodus binotatus Schultz, 1953: [1992]
Synodus rubromarmoratus Russell & Cressey, 1979: [1992 – WAM 30403.013]

Synodus variegatus (Lacepède, 1803): [1992]
Trachinocephalus myops (Forster, 1801): [2008]

Carapidae (1)
Encheliophis homei (Richardson, 1846): [1992 – WAM 30397.049]

Batrachoididae (1)
Allenbatrachus reticulatus (Steindachner, 1870): [1992 – WAM 30397.014]

Antennariidae (4)
Antennarius commerson (Lacepède, 1798): [2006]
Antennarius pictus (Shaw, 1794): [1992]
Antennarius striatus (Shaw, 1794): [2008]
Lophiocharon lithinostomus (Jordan & Richardson, 1908): [(Swann 2007)]

Atherinidae (1)
Atherinomorus lacunosus (Forster, 1801): [2008, 2009]

Belonidae (2)
Strongylura incisa (Valenciennes, 1846): [2008]
Tylosurus crocodilus (Péron & Lesueur, 1821): [2008]

Hemiramphidae (2)
Hyporhamphus dussumieri (Valenciennes, 1847): [2009]
Zenarchopterus gilli Smith, 1945: [1992]

Holocentridae (2)
Myripristis hexagona (Lacepède, 1802): [1992, 2009]
Sargocentron rubrum (Forsskål, 1775): [1992, 2009]

Aulostomidae (1)
Aulostomus chinensis (Linnaeus, 1766): [2007, 2009]

Fistulariidae (2)
Fistularia commersonii Rüppell, 1838: [1992, 2009]
Fistularia petimba Lacepède, 1803: [2008]

Centriscidae (2)
Aeoliscus strigatus (Günther, 1861): [1992, 2009]
Centriscus scutatus Linnaeus, 1758: [2007, 2009]

Solenostomidae (2)
Solenostomus cyanopterus Bleeker, 1854: [2008]
Solenostomus paradoxus (Pallas, 1770): [2008]

Syngnathidae (3)
Dunckerocampus dactyliophorus (Bleeker, 1853): [1992, 2009]
Hippocampus sp.: [(Swann 2011a)]
Trachyrhamphus bicoarctatus (Bleeker, 1857): [2006, 2008]

Scorpaenidae (11)
Dendrochirus zebra (Cuvier, 1829): [1992, 2008]
Parascorpaena picta (Cuvier, 1829): [1992 – WAM 30397.013/ 30400.018/ 30403.018, 2006]
Pterois antennata (Bloch, 1787): [2007, 2008]
Pterois russelii Bennett, 1831: [2007, 2008]
Pterois volitans (Linnaeus, 1758): [2006, 2009]
Rhinopias frondosa (Günther, 1892) : [(Swann 2011b)]
Scorpaenopsis diabolus (Cuvier, 1829): [2007, 2008]
Scorpaenopsis oxycephala (Bleeker, 1849): [2007, 2008]
Scorpaenopsis possi Randall & Eschmeyer, 2001: [2007, 2008]
Scorpaenopsis venosa (Cuvier, 1829): [2007, 2008]
Taenianotus triacanthus Lacepède, 1802: [2008]

Tetrarogidae (1)
Ablabys taenianotus (Cuvier, 1829): [2007, 2008]

Synanceiidae (4)
Inimicus didactylus (Pallas, 1769): [1992, 2008]
Inimicus sinensis (Valenciennes, 1833): [2008]
Synanceia horrida (Linnaeus, 1766) : [2007, 2009]
Synanceia verrucosa Bloch & Schneider, 1801: [2007, 2008]

Aploactinidae (1)
Paraploactis obbesi (Weber, 1913): [2008]

Platycephalidae (2)
Cymbacephalus beauforti (Knapp, 1973): [1992, 2007]
Platycephalus indicus (Linnaeus, 1758): [2009]

Ambassidae (1)
Ambassis gymnocephala (Lacepède, 1802): [1992 – WAM 30397.021, 2009]

Latidae (1)
Psammoperca waigiensis (Cuvier, 1828): [1992]

Serranidae (13)
Cephalopholis boenak (Bloch, 1790): [1992 – WAM 30397.052, 2009]
Cephalopholis cyanostigma (Valenciennes, 1828): [1992, 2009]
Cephalopholis formosa (Shaw, 1812) : [1992, 2009]
Cephalopholis microprion (Bleeker, 1852): [1992, 2009]
Diploprion bifasciatum Cuvier, 1828: [1992, 2009]
Epinephelus areolatus (Forsskål, 1775): [2007, 2008]
Epinephelus fasciatus (Forsskål, 1775): [1992, 2009]
Epinephelus merra Bloch, 1793: [2006, 2009]
Epinephelus ongus (Bloch, 1790): [2006, 2008]
Epinephelus quoyanus (Valenciennes, 1830): [1992]
Epinephelus undulosus (Quoy & Gaimard, 1824): [2008]
Plectropomus leopardus (Lacepède, 1802): [2009]
Plectropomus maculatus (Bloch, 1790): [1992, 2009]

Pseudochromidae (1)
Pseudochromis fuscus Müller & Troschel, 1849: [2009]

Plesiopidae (2)
Calloplesiops altivelis (Steindachner, 1903): [2007]
Plesiops coeruleolineatus Rüppell, 1835: [1992 – WAM 30400.01]

Terapontidae (3)
Eutherapon theraps Cuvier, 1829: [2008, 2009]
Pelates quadrilineatus (Bloch, 1790): [1992 – WAM 30397.007]
Terapon jarbua (Forsskål, 1775): [2007]

Apogonidae (51)
Apogon indicus Greenfield, 2001: [1992]
Apogonichthyoides melas Bleeker, 1848: [1992]

Apogonichthyoides timorensis (Bleeker, 1854): [1992 – WAM 30397.04, 2008]
Archamia bleekeri (Günther, 1859): [2008, 2009]
Cheilodipterus alleni Gon, 1993: [2006, 2007]
Cheilodipterus artus Smith, 1961: [1992, 2009]
Cheilodipterus intermedius Gon, 1993: [2006]
Cheilodipterus isostigmus (Schultz, 1940): [2007, 2009]
Cheilodipterus macrodon (Lacepède, 1802): [1992, 2009]
Cheilodipterus quinquelineatus Cuvier, 1828: [1992 – WAM 30403.016, 2009]
Cheilodipterus singapurensis Bleeker, 1860: [2007]
Fibramia lateralis (Valenciennes, 1832): [1992]
Fowleria variegata (Valenciennes, 1832): [1992 – WAM 30397.006]
Gymnapogon philippinus (Herre, 1939): [1992 – WAM 30397.029]
Nectamia fusca (Quoy & Gaimard, 1825): [1992]
Nectamia similis Fraser, 2008: [2007, 2009]
Ostorhinchus aureus (Lacepède, 1802): [2007]
Ostorhinchus cavitensis (Jordan & Seale, 1907): [1992 – WAM 30402.001]
Ostorhinchus chrysopomus (Bleeker, 1854): [1992 – WAM 30397.034/30403.015, 2009]
Ostorhinchus compressus (Smith & Radcliffe, 1911): [1992, 2009]
Ostorhinchus cookii (Macleay, 1881): [1992 – WAM 30403.004]
Ostorhinchus endekataenia (Bleeker, 1852): [1992, 2009]
Ostorhinchus griffini (Seale, 1910): [1992 – WAM 30399.001/30399.012, 2009]
Ostorhinchus hartzfeldii (Bleeker, 1852): [2009]
Ostorhinchus moluccensis (Valenciennes, 1832): [2006, 2009]
Ostorhinchus multilineatus (Bleeker, 1874): [1992 – WAM 30397.008, 2008]
Ostorhinchus nanus (Allen, Kuiter & Randall, 1994): [1992 – WAM 30402.002, 2009]
Ostorhinchus neotes (Allen, Kuiter & Randall, 1994): [2007]
Ostorhinchus nigrofasciatus (Lachner, 1953): [2008]
Ostorhinchus parvulus (Smith & Radcliffe, 1912): [1992, 2009]
Ostorhinchus sealei (Fowler, 1918): [2008]
Ostorhinchus taeniophorus (Regan, 1908): [1992 – WAM 30399.003/30400.016]
Ostorhinchus wassinki (Bleeker, 1861): [1992, 2009]
Pristiapogon fraenatus (Valenciennes, 1832): [2009]
Pristicon rhodopterus (Bleeker, 1852): [2006, 2009]
Pristicon trimaculatus (Cuvier, 1828): [1992 – WAM 30397.036, 2008]
Pseudamia gelatinosa Smith, 1956: [2008]
Rhabdamia cypselurus Weber, 1909: [2007, 2009]
Rhabdamia gracilis (Bleeker, 1856): [1992, 2009]
Siphamia corallicola Allen, 1993: [1992 WAM 30402.005 /30405.014]
Siphamia elongata Lachner, 1953: [2008]
Siphamia tubifer Weber, 1909: [2008]
Sphaeramia nematoptera (Bleeker, 1856): [(Swann 2010)]
Sphaeramia orbicularis (Cuvier, 1828): [1992, 2009]
Taeniamia biguttata (Lachner, 1951): [1992, 2008]
Taeniamia fucata (Cantor, 1849): [1992, 2009]
Taeniamia macroptera (Cuvier, 1828): [1992 – WAM 30403.014, 2009]
Taeniamia melasma Lachner & Taylor, 1960: [2006, 2009]
Taeniamia zosterophora (Bleeker, 1856): [1992, 2009]
Zoramia fragilis (Smith, 1961): [1992, 2008]
Zoramia leptacantha (Bleeker, 1856): [1992 – WAM 30397.033]

Sillaginidae (1)
Sillago sihama (Forsskål, 1775): [1992]

Rachycentridae (1)
Rachycentron canadum (Linnaeus, 1766): [(Swann 2011c)]

Echeneidae (1)
Echeneis naucrates Linnaeus, 1758: [2007, 2009]

Carangidae (12)
Alepes vari (Cuvier, 1833): [1992, 2008]
Atule mate (Cuvier, 1833): [2008, 2009]
Carangoides coeruleopinnatus (Rüppell, 1830): [1992 – WAM 30399.007]
Carangoides orthogrammus (Jordan & Gilbert, 1882): [1992]
Caranx melampygus Cuvier, 1833: [1992, 2008]
Caranx sexfasciatus Quoy & Gaimard, 1825: [1992]
Elagatis bipinnulata (Quoy & Gaimard, 1825): [2008]
Gnathanodon speciosus (Forsskål, 1775): [1992, 2009]
Scomberoides commersonnianus Lacepède, 1801: [2006]
Scomberoides lysan (Forsskål, 1775): [2008]
Selar crumenophthalmus (Bloch, 1793): [1992 – WAM 30403.003, 2009]
Selaroides leptolepis (Cuvier, 1833): [1992]

Leiognathidae (2)
Gazza minuta (Bloch, 1795): [2009]
Nuchequula gerreoides (Bleeker, 1851): [1992 – WAM 30399.004]

Lutjanidae (12)
Lutjanus argentimaculatus (Forsskål, 1775): [2008]
Lutjanus biguttatus (Valenciennes, 1830): [1992, 2009]
Lutjanus bohar (Forsskål, 1775): [1992]
Lutjanus carponotatus (Richardson, 1842): [1992, 2008]
Lutjanus decussatus (Cuvier, 1828): [1992, 2009]
Lutjanus fulviflamma (Forsskål, 1775): [1992, 2008]
Lutjanus lutjanus Bloch, 1790: [1992 – WAM 30402.003, 2009]
Lutjanus monostigma (Cuvier, 1828): [2007, 2008]
Lutjanus quinquelineatus (Bloch, 1790): [2006, 2008]
Lutjanus sebae (Cuvier, 1816): [2007, 2008]
Lutjanus vitta (Quoy & Gaimard, 1824): [1992, 2009]
Macolor niger (Forsskål, 1775): [1992]

Caesionidae (5)
Caesio caerulaurea Lacepède, 1801: [1992, 2009]
Caesio cuning (Bloch, 1791): [1992]
Caesio teres Seale, 1906: [2006, 2009]
Pterocaesio chrysozona (Cuvier, 1830): [1992, 2009]
Pterocaesio pisang (Bleeker, 1853): [1992 – WAM 30402.012]

Gerreidae (1)
Gerres oyena (Forsskål, 1775): [2006, 2009]

Haemulidae (5)
Diagramma melanacrum Johnson & Randall 2001: [2006, 2008]
Plectorhinchus chaetodonoides Lacepède, 1801: [1992, 2009]
Plectorhinchus flavomaculatus (Cuvier, 1830): [2008, 2009]
Plectorhinchus gibbosus (Lacepède, 1802): [1992, 2008]
Plectorhinchus lessonii (Cuvier, 1830): [1992, 2006]

Lethrinidae (6)
Lethrinus atkinsoni Seale, 1910: [1992]
Lethrinus erythropterus Valenciennes, 1830: [2008]
Lethrinus harak (Forsskål, 1775): [1992, 2009]
Lethrinus lentjan (Lacepède, 1802): [1992]
Lethrinus ornatus Valenciennes, 1830: [1992 – WAM 30403.01]
Lethrinus variegatus Valenciennes, 1830: [1992]

Nemipteridae (11)
Pentapodus caninus (Cuvier, 1830): [2007, 2008]
Pentapodus emeryii (Richardson, 1843): [1992, 2009]
Pentapodus setosus (Valenciennes, 1830): [1992]
Pentapodus trivittatus (Bloch, 1791): [1992, 2009]
Scolopsis affinis Peters, 1877: [1992, 2009]
Scolopsis bilineata (Bloch, 1793): [1992, 2009]
Scolopsis ciliata (Lacepède, 1802): [1992, 2009]
Scolopsis lineata Quoy & Gaimard, 1824: [1992, 2009]
Scolopsis margaritifera (Cuvier, 1830): [1992 – WAM 30397.047, 2009]
Scolopsis monogramma (Cuvier, 1830): [1992, 2008]
Scolopsis vosmeri (Bloch, 1792): [1992 – WAM 30402.008, 2008]

Mullidae (5)
Mulloidichthys flavolineatus (Lacepède, 1801): [1992, 2009]
Parupeneus barberinus (Lacepède, 1801): [1992, 2009]
Parupeneus indicus (Shaw, 1803): [1992, 2009]
Parupeneus multifasciatus (Quoy & Gaimard, 1825): [1992, 2009]
Upeneus tragula Richardson, 1846: [1992, 2009]

Pempheridae (4)
Pempheris adusta Bleeker, 1877: [2006, 2008]
Pempheris molucca Cuvier, 1829: [2007, 2009]
Pempheris oualensis Cuvier, 1831: [1992, 2008]
Pempheris vanicolensis Cuvier, 1831: [1992, 2009]

Toxotidae (1)
Toxotes jaculatrix (Pallas, 1767): [2008]

Kyphosidae (1)
Kyphosus vaigiensis (Quoy & Gaimard, 1825): [2008]

Chaetodontidae (20)
Chaetodon adiergastos Seale, 1910: [1992, 2009]
Chaetodon auriga Forsskål, 1775: [1992, 2009]
Chaetodon baronessa Cuvier, 1829: [1992, 2008]
Chaetodon bennetti Cuvier, 1831: [1992]
Chaetodon lineolatus Cuvier, 1831: [1992]
Chaetodon lunula (Lacepède, 1802): [1992, 2009]
Chaetodon lunulatus Quoy & Gaimard, 1825: [1992, 2008]
Chaetodon melannotus Bloch & Schneider, 1801: [2006]
Chaetodon ocellicaudus Cuvier, 1831: [1992]
Chaetodon octofasciatus Bloch, 1787: [1992 – WAM 30397.053, 2009]
Chaetodon oxycephalus Bleeker, 1853: [1992]
Chaetodon rafflesii Anonymous [Bennett], 1830: [2007, 2008]
Chaetodon speculum Cuvier, 1831: [1992]
Chaetodon trifascialis Quoy & Gaimard, 1825: [1992, 2008]
Chaetodon vagabundus Linnaeus, 1758: [1992]
Chelmon rostratus (Linnaeus, 1758): [1992, 2009]
Coradion chrysozonus (Cuvier, 1831): [1992, 2009]
Heniochus acuminatus (Linnaeus, 1758): [2007, 2009]
Heniochus singularius Smith & Radcliffe, 1911: [1992, 2009]
Parachaetodon ocellatus (Cuvier 1831): [1992, 2008]

Pomacanthidae (6)
Centropyge bicolor (Bloch, 1787): [2008]
Chaetodontoplus mesoleucus (Bloch, 1787): [1992, 2009]
Pomacanthus annularis (Bloch, 1787): [1992, 2009]
Pomacanthus semicirculatus (Cuvier, 1831): [2009]
Pomacanthus sexstriatus (Cuvier, 1831): [2006, 2009]
Pygoplites diacanthus (Boddaert, 1772): [2008]

Mugilidae (4)
Crenimugil crenilabis (Forsskål, 1775): [2007, 2008]
Ellochelon vaigiensis (Quoy & Gaimard, 1825): [1992]
Liza tade (Forsskål, 1775): [2008]
Moolgarda engeli (Bleeker, 1858): [2008]

Pomacentridae (71)
Abudefduf bengalensis (Bloch, 1787): [1992 – WAM 30400.015, 2009]
Abudefduf lorenzi Hensley & Allen, 1977: [1992, 2009]
Abudefduf notatus (Day, 1870): [1992]
Abudefduf septemfasciatus (Cuvier, 1830): [1992, 2009]
Abudefduf sexfasciatus (Lacepède, 1801): [1992 – WAM 30400.021, 2009]
Abudefduf sordidus (Forsskål, 1775): [1992 – WAM 30400.02, 2009]
Abudefduf vaigiensis (Quoy & Gaimard, 1825): [1992 – WAM 30400.007, 2008]
Amblyglyphidodon aureus (Cuvier, 1830): [1992, 2009]
Amblyglyphidodon curacao (Bloch, 1787): [1992, 2009]
Amblyglyphidodon leucogaster (Bleeker, 1847): [1992, 2008]
Amblyglyphidodon ternatensis (Bleeker, 1853): [1992, 2009]
Amblypomacentrus breviceps (Schlegel & Müller, 1840):

[1992 – WAM 30397.022/ 30403.02, 2009]
Amphiprion clarkii (Bennett, 1830): [1992, 2009]
Amphiprion frenatus Brevoort, 1856: [2006, 2008]
Amphiprion ocellaris Cuvier, 1830: [1992, 2009]
Amphiprion perideraion Bleeker, 1855: [1992, 2009]
Amphiprion polymnus (Linnaeus, 1758): [2006, 2009]
Amphiprion sandaracinos Allen, 1972: [1992, 2009]
Cheiloprion labiatus (Day, 1877): [1992 – WAM 30397.045, 2009]
Chromis atripectoralis Welander & Schultz, 1951: [1992, 2009]
Chromis cinerascens (Cuvier, 1830): [1992, 2009]
Chromis ternatensis (Bleeker, 1856): [1992, 2009]
Chromis viridis (Cuvier, 1830): [1992, 2008]
Chromis weberi Fowler & Bean, 1928: [1992]
Chrysiptera oxycephala (Bleeker, 1877): [1992, 2009]
Chrysiptera parasema (Fowler, 1918): [1992, 2008]
Chrysiptera rollandi (Whitley, 1961): [1992, 2009]
Chrysiptera springeri (Allen & Lubbock, 1976): [1992 – WAM 30399.008, 2008]
Chrysiptera unimaculata (Cuvier, 1830): [1992, 2009]
Dascyllus aruanus (Linnaeus, 1758): [2006, 2009]
Dascyllus melanurus Bleeker, 1854: [1992 – WAM 30397.051, 2009]
Dascyllus reticulatus (Richardson, 1846): [1992, 2009]
Dascyllus trimaculatus (Rüppell, 1829: [1992, 2009]
Dischistodus chrysopoecilus (Schlegel & Müller, 1840): [1992 – WAM 30397.031, 2009]
Dischistodus fasciatus (Cuvier, 1830): [1992 – WAM 30397.002/ 30400.019, 2009]
Dischistodus melanotus (Bleeker, 1858): [1992 – WAM 30397.054, 2008]
Dischistodus perspicillatus (Cuvier, 1830): [1992 – WAM 30397.039, 2009]
Dischistodus prosopotaenia (Bleeker, 1852): [1992, 2009]
Hemiglyphidodon plagiometopon (Bleeker, 1852): [1992, 2009]
Neoglyphidodon melas (Cuvier, 1830): [1992, 2009]
Neoglyphidodon nigroris (Cuvier, 1830): [1992, 2009]
Neoglyphidodon oxyodon (Bleeker, 1858): [1992, 2008]
Neopomacentrus anabatoides (Bleeker, 1847): [1992 – WAM 30399.009, 2009]
Neopomacentrus azysron (Bleeker, 1877): [2008]
Neopomacentrus bankieri (Richardson, 1846): [1992 – WAM 30402.011]
Neopomacentrus cyanomos (Bleeker, 1856): [1992, 2009]
Neopomacentrus filamentosus (Macleay, 1882): [1992 – WAM 30403.001, 2009]
Plectroglyphidodon dickii (Liénard, 1839): [1992, 2008]
Plectroglyphidodon lacrymatus (Quoy & Gaimard, 1825): [1992, 2009]
Plectroglyphidodon leucozonus (Bleeker, 1859): [1992]
Pomacentrus adelus Allen, 1991: [1992, 2009]
Pomacentrus alexanderae Evermann & Seale, 1907: [1992, 2009]
Pomacentrus amboinensis Bleeker, 1868: [1992, 2009]
Pomacentrus burroughi Fowler, 1918: [1992, 2009]
Pomacentrus chrysurus Cuvier, 1830: [1992 – WAM 30397.032, 2008]
Pomacentrus coelestis Jordan & Starks, 1901: [1992, 2009]
Pomacentrus cuneatus Allen, 1991: [1992 – WAM 30402.006/ 30403.021, 2008]
Pomacentrus grammorhynchus Fowler, 1918: [1992, 2009]
Pomacentrus lepidogenys Fowler & Bean, 1928: [1992, 2009]
Pomacentrus moluccensis Bleeker, 1853: [1992, 2009]
Pomacentrus nagasakiensis Tanaka, 1917: [1992, 2009]
Pomacentrus philippinus Evermann & Seale, 1907: [2009]
Pomacentrus simsiang Bleeker, 1856: [1992, 2009]
Pomacentrus smithi Fowler & Bean, 1928: [2007, 2009]
Pomacentrus stigma Fowler & Bean, 1928: [1992, 2009]
Pomacentrus tripunctatus Cuvier, 1830: [1992 – WAM 30397.003/ 30400.017, 2009]
Pomacentrus vaiuli Jordan & Seale, 1906: [1992, 2009]
Premnas biaculeatus (Bloch, 1790): [1992, 2009]
Stegastes fasciolatus (Ogilby, 1889): [2009]
Stegastes obreptus (Whitley, 1948): [1992]
Stegastes punctatus (Quoy & Gaimard, 1825): [1992]

Labridae (55)

Anampses meleagrides Valenciennes, 1840: [2009]
Bodianus mesothorax (Bloch & Schneider, 1801): [1992, 2009]
Cheilinus chlorourus (Bloch, 1791): [1992 – WAM 30397.037/ 046, 2006]
Cheilinus fasciatus (Bloch, 1791): [1992, 2009]
Cheilinus trilobatus Lacepède, 1801: [1992, 2009]
Cheilinus undulatus Rüppell, 1835: [1992 – WAM 30397.058]
Cheilio inermis (Forsskål, 1775): [1992, 2008]
Choerodon anchorago (Bloch, 1791): [1992, 2008]
Cirrhilabrus cyanopleura (Bleeker, 1851): [1992, 2009]
Cirrhilabrus temminckii Bleeker, 1853: [1992]
Coris batuensis (Bleeker, 1856): [1992, 2009]
Coris gaimard (Quoy & Gaimard, 1824): [1992]
Diproctacanthus xanthurus (Bleeker, 1856): [1992, 2009]
Epibulus insidiator (Pallas, 1770): [1992, 2009]
Gomphosus varius Lacepède, 1801: [1992, 2009]
Halichoeres argus (Bloch & Schneider, 1801): [1992 – WAM 30397.027, 2009]
Halichoeres chloropterus (Bloch, 1791): [1992, 2009]
Halichoeres hartzfeldii (Bleeker, 1852): [1992 – WAM 30402.009]
Halichoeres kneri Bleeker, 1862: [2008, 2009]
Halichoeres leucurus (Walbaum, 1792): [1992, 2009]
Halichoeres margaritaceus (Valenciennes, 1839): [1992, 2008]
Halichoeres marginatus Rüppell, 1835: [1992]
Halichoeres melanochir Fowler & Bean, 1928: [1992, 2009]
Halichoeres melanurus (Bleeker, 1851): [1992, 2009]
Halichoeres miniatus (Valenciennes, 1839): [2008]
Halichoeres nigrescens (Bloch & Schneider, 1801): [1992, 2008]

Halichoeres podostigma (Bleeker, 1854): [2009]
Halichoeres prosopeion (Bleeker, 1853): [2008, 2009]
Halichoeres scapularis (Bennett, 1832): [1992, 2009]
Halichoeres trimaculatus (Quoy & Gaimard, 1834): [1992]
Hemigymnus fasciatus (Bloch, 1792): [1992, 2009]
Hemigymnus melapterus (Bloch, 1791): [1992, 2009]
Iniistius melanopus (Bleeker, 1857): [2008]
Labrichthys unilineatus (Guichenot, 1847): [1992, 2009]
Labroides dimidiatus (Valenciennes, 1839): [1992, 2009]
Leptojulis cyanopleura (Bleeker, 1853): [2008, 2009]
Macropharyngodon meleagris (Valenciennes, 1839): [1992, 2008]
Macropharyngodon negrosensis Herre, 1932: [1992, 2009]
Macropharyngodon ornatus Randall, 1978: [2007]
Novaculichthys taeniourus (Lacepède, 1801): [1992, 2009]
Oxycheilinus bimaculatus (Valenciennes, 1840): [2008]
Oxycheilinus celebicus (Bleeker, 1853): [1992, 2009]
Oxycheilinus digramma (Lacepède, 1801): [2007, 2009]
Oxycheilinus orientalis (Günther, 1862): [2007, 2009]
Paracheilinus carpenteri Randall & Lubbock, 1981: [2008]
Pseudocheilinus hexataenia (Bleeker, 1857): [2009]
Pteragogus cryptus Randall, 1981: [2008, 2009]
Pteragogus enneacanthus (Bleeker, 1853): [1992 – WAM 30397.044/ 30399.002]
Pteragogus flagellifer (Valenciennes, 1839): [1992]
Pteragogus guttatus (Fowler & Bean, 1928): [2008]
Stethojulis interrupta (Bleeker, 1851): [1992 – WAM 30397.019, 2009]
Stethojulis trilineata (Bloch & Schneider, 1801): [1992, 2009]
Thalassoma hardwicke (Bennett, 1830): [1992, 2009]
Thalassoma lunare (Linnaeus, 1758): [1992, 2009]
Xenojulis margaritaceus (Macleay, 1883): [1992]

Scaridae (22)

Bolbometopon muricatum (Valenciennes, 1840): [2009]
Cetoscarus ocellatus (Rüppell, 1829): [1992]
Chlorurus bleekeri (de Beaufort, 1940): [1992, 2008]
Chlorurus capistratoides (Bleeker, 1847): [2009]
Chlorurus sordidus (Forsskål, 1775): [1992, 2009]
Hipposcarus longiceps (Valenciennes, 1840): [2007]
Leptoscarus vaigiensis (Quoy & Gaimard, 1824): [1992, 2008]
Scarus dimidiatus Bleeker, 1859: [1992, 2008]
Scarus flavipectoralis Schultz, 1958: [1992]
Scarus forsteni (Bleeker, 1861): [2009]
Scarus frenatus Lacepède, 1802: [1992]
Scarus ghobban Forsskål, 1775: [1992, 2009]
Scarus globiceps Valenciennes, 1840: [1992]
Scarus hypselopterus Bleeker, 1853: [1992, 2009]
Scarus niger Forsskål, 1775: [1992, 2009]
Scarus oviceps Valenciennes, 1840: [1992, 2008]
Scarus prasiognathos Valenciennes, 1840: [1992]
Scarus psittacus Forsskål, 1775: [1992, 2009]
Scarus quoyi Valenciennes, 1840: [1992, 2009]
Scarus rivulatus Valenciennes, 1840: [2006, 2009]
Scarus schlegeli (Bleeker, 1861): [2007, 2009]
Scarus spinus (Kner, 1868): [1992, 2009]

Uranoscopidae (1)

Uranoscopus bicinctus Temminck & Schlegel, 1843: [2008]

Trichonotidae (2)

Trichonotus elegans Shimada & Yoshino, 1984: [2008]
Trichonotus setiger Bloch & Schneider, 1801: [2008]

Pinguipedidae (5)

Parapercis clathrata Ogilby, 1910: [1992, 2008]
Parapercis cylindrica (Bloch, 1792): [1992]
Parapercis pacifica Imamura & Yoshino 2007: [1992, 2008]
Parapercis lineopunctata Randall, 2003: [2008]
Parapercis xanthozona (Bleeker, 1849): [1992, 2009]

Pholidichthyidae (1)

Pholidichthys leucotaenia Bleeker, 1856: [2007, 2008]

Tripterygiidae (4)

Enneapterygius minutus (Günther, 1877): [1992]
Enneapterygius sp.: [1992 – WAM 30400.013/025]
Helcogramma capidata Rosenblatt, 1960: [1992 – WAM 30400.027]
Helcogramma striata Hansen, 1986: [1992, 2009]

Blenniidae (24)

Andamia heteroptera (Bleeker, 1857): [2008]
Andamia tetradactylus (Bleeker, 1858): [1992 – WAM 30400.001]
Atrosalarias fuscus (Rüppell, 1838): [1992]
Blenniella bilitonensis (Bleeker, 1858): [1992]
Ecsenius bicolor (Day, 1888): [1992, 2009]
Ecsenius monoculus Springer, 1988: [1992, 2009]
Ecsenius trilineatus Springer, 1972: [2007, 2009]
Ecsenius yaeyamaensis (Aoyagi, 1954): [1992, 2009]
Entomacrodus decussatus (Bleeker, 1858): [1992 – WAM 30400.005/30403.022]
Entomacrodus thalassinus (Jordan & Seale, 1906): [1992 – WAM 30400.023]
Istiblennius edentulus (Forster & Schneider, 1801): [1992 – WAM 30400.004/30403.023, 2009]
Meiacanthus geminatus Smith-Vaniz, 1976: [1992 – WAM 30403.006, 2009]
Meiacanthus grammistes (Valenciennes, 1836): [1992]
Nannosalarias nativitatis (Regan, 1909): [2008]
Paralticus amboinensis (Bleeker 1857): [1992]
Petroscirtes breviceps (Valenciennes, 1836): [2008, 2009]
Petroscirtes variabilis Cantor, 1849: [1992 – WAM 30397.025/30403.005, 2009]
Plagiotremus rhinorhynchos (Bleeker, 1852): [1992, 2009]
Praealticus bilineatus (Peters 1868): [1992 – WAM 30400.006]
Rhabdoblennius nitidus (Günther, 1861): [1992]
Salarias fasciatus (Bloch, 1786): [1992 – WAM 30400.022, 2009]
Salarias guttatus Valenciennes, 1836: [1992, 2009]
Salarias obscurus Bath, 1992: [2008, 2009]
Salarias sinuosus Snyder, 1908: [1992]

Callionymidae (4)

Anaora tentaculata Gray, 1835: [1992, 2009]
Callionymus enneactis Bleeker, 1879: [1992 – WAM 30398.009]
Diplogrammus goramensis (Bleeker, 1858), [1992 – WAM 30397.042]
Synchiropus splendidus (Herre, 1927): [2009]

Gobiidae (68)

Acentrogobius nebulosus (Forsskål, 1775): [1992 – WAM 30397.009]
Amblyeleotris diagonalis Polunin & Lubbock, 1979: [2008, 2009]
Amblyeleotris gymnocephala (Bleeker, 1853): [2006, 2008]
Amblyeleotris japonica Takagi, 1957: [1992]
Amblyeleotris latifasciata Polunin & Lubbock, 1979: [2008]
Amblyeleotris periophthalma (Bleeker, 1853): [2008]
Amblyeleotris rubrimarginata Mohlmann & Randall 2002: [1992 – WAM 30398.008, 2008]
Amblyeleotris steinitzi (Klausewitz, 1974): [1992 – WAM 30397.056, 2008]
Amblyeleotris wheeleri Polunin & Lubbock, 1977: [1992]
Amblygobius albimaculatus (Rüppell, 1830): [1992 – WAM 30397.016/30398.006, 2009]
Amblygobius buanensis Herre, 1927: [2008]
Amblygobius stenophthalmus (Bleeker, 1851): [1992 – WAM 30397.015]
Amblygobius nocturnus (Herre, 1945): [1992 – WAM 30397.055/ 30398.005, 2009]
Asterropteryx semipunctata Rüppell, 1830: [1992]
Asterropteryx striata Allen & Munday, 1995: [1992, 2009]
Bathygobius cyclopterus (Valenciennes, 1837): [1992 – WAM 30400.008]
Bryaninops loki Larson, 1985: [2008]
Bryaninops yongei (Davis & Cohen, 1969): [2007]
Cabillus lacertops Smith, 1959: [1992 – WAM 30397.03]
Callogobius okinawae (Snyder, 1908): [1992 – WAM 30400.009]
Cryptocentrus caeruleomaculatus (Herre, 1933): [2009]
Cryptocentrus cinctus (Herre, 1936): [1992 – WAM 30398.002, 2008]
Cryptocentrus fasciatus (Playfair, 1867): [1992 – WAM 30403.002, 2008]
Cryptocentrus inexplicatus (Herre, 1934): [2008]
Cryptocentrus leptocephalus Bleeker, 1876: [1992 – WAM 30398.001, 2009]
Cryptocentrus nigrocellatus (Yanagisawa, 1978): [1992]
Cryptocentrus sericus Herre, 1932: [2008]
Ctenogobiops maculosus (Fourmanoir, 1955): [2008]
Ctenogobiops pomastictus Lubbock & Polunin, 1977: [1992 – WAM 30397.018/ 30403.008, 2007]
Eviota atriventris Greenfield & Suzuki, 2012: [2007, 2009]
Eviota bifasciata Lachner & Karnella, 1980: [1992, 2007]
Eviota guttata Lachner & Karnella, 1978: [2009]
Eviota lachdeberei Giltay, 1933: [1992]
Eviota prasina (Klunzinger, 1871): [1992 – WAM 30400.014]
Eviota prasites Jordan & Seale, 1906: [2007, 2009]
Eviota sebreei Jordan & Seale, 1906: [2007, 2009]
Eviota sigillata Jewett & Lachner, 1983: [2009]
Exyrias belissimus (Smith, 1959): [1992, 2009]
Fusigobius inframaculatus (Randall, 1994): [2006, 2009]
Fusigobius melacron (Randall, 2001): [2008]
Gobiodon okinawae Sawada, Arai & Abe, 1972: [1992 – WAM 30401.002]
Gobiodon rivulatus (Rüppell, 1830): [1992]
Gobiopsis arenaria (Snyder, 1908): [1992 – WAM 30400.012]
Istigobius decoratus (Herre, 1927): [2008, 2009]
Istigobius goldmanni (Bleeker, 1852): [1992 – WAM 30397.017]
Istigobius nigroocellatus (Günther, 1873): [1992 – WAM 30403.024]
Istigobius ornatus (Rüppell, 1830): [1992 – WAM 30399.006, 2008]
Koumansetta hectori (Smith, 1957): [1992, 2009]
Macrodontogobius wilburi Herre, 1936: [1992]
Mahidolia mystacina (Valenciennes, 1837): [2009]
Oplopomus caninoides (Bleeker, 1852): [2008, 2009]
Oplopomus oplopomus (Valenciennes, 1837): [1992 – WAM 30397.004/ 30398.003, 2009]
Pleurosicya boldinghi Weber, 1913: [2008]
Pleurosicya micheli Fourmanoir, 1971: [2006, 2009]
Pleurosicya mossambica Smith, 1959: [2008]
Priolepis semidoliata (Valenciennes, 1837): [1992 – WAM 30397.057]
Trimma naudei Smith, 1957: [2007]
Trimma striatum (Herre, 1945): [1992, 2009]
Valenciennea helsdingenii (Bleeker, 1858): [1992]
Valenciennea immaculata (Ni, 1981): [2008]
Valenciennea longipinnis (Lay & Bennett, 1839): [1992 – WAM 30397.001]
Valenciennea muralis (Valenciennes, 1837): [2006, 2008]
Valenciennea parva Hoese & Larson, 1994: [1992 – WAM 30397.059/ 30398.007]
Valenciennea puellaris (Tomiyama, 1956): [1992, 2008]
Valenciennea sexguttata (Valenciennes, 1837): [1992, 2009]
Vanderhorstia ambanoro (Fourmanoir, 1957): [1992, 2008]
Vanderhorstia nobilis Allen & Randall, 2006: [2008]
Vanderhorstia wayag Allen & Erdmann, 2012: [2008]

Microdesmidae (10)

Aioliops brachypterus Rennis & Hoese, 1987: [1992]
Aioliops megastigma Rennis & Hoese, 1987: [1992, 2009]
Gunnellichthys monostigma Smith, 1958: [1992]
Gunnellichthys viridescens Dawson, 1968: [2008]
Parioglossus formosus (Smith, 1931): [1992]
Parioglossus philippinus (Herre, 1945): [2008, 2009]
Parioglossus rainfordi McCulloch, 1921: [2009]
Ptereleotris evides (Jordan & Hubbs, 1925): [2008]
Ptereleotris hanae (Jordan & Snyder, 1901): [2008]
Ptereleotris microlepis (Bleeker, 1856): [1992]

Ephippidae (2)
Platax pinnatus (Linnaeus, 1758): [1992, 2009]
Platax teira (Forsskål, 1775): [1992, 2009]

Siganidae (10)
Siganus argenteus (Quoy & Gaimard, 1825): [1992]
Siganus corallinus (Valenciennes, 1835): [2008]
Siganus fuscescens (Houttuyn, 1782): [1992 – WAM 30397.028, 2009]
Siganus guttatus (Bloch, 1787): [1992, 2009]
Siganus javus (Linnaeus, 1766): [1992, 2009]
Siganus puellus (Schlegel, 1852): [1992, 2007]
Siganus punctatus (Schneider & Forster, 1801): [1992]
Siganus spinus (Linnaeus, 1758): [2008, 2009]
Siganus virgatus (Valenciennes, 1835): [1992 – WAM 30397.048, 2009]
Siganus vulpinus (Schlegel & Müller, 1845): [2007, 2009]

Zanclidae (1)
Zanclus cornutus (Linnaeus, 1758): [1992, 2008]

Acanthuridae (8)
Acanthurus blochii Valenciennes, 1835: [1992]
Acanthurus mata (Cuvier, 1829): [1992]
Acanthurus xanthopterus Valenciennes, 1835: [2008, 2009]
Ctenochaetus binotatus Randall, 1955: [2008, 2009]
Ctenochaetus striatus (Quoy & Gaimard, 1825): [1992, 2009]
Naso brevirostris (Cuvier, 1829): [1992]
Naso lituratus (Forster, 1801): [1992]
Zebrasoma scopas (Cuvier, 1829): [2007]

Sphyraenidae (4)
Sphyraena barracuda (Edwards, 1771): [1992, 2008]
Sphyraena flavicauda Rüppell, 1838: [1992, 2009]
Sphyraena jello Cuvier, 1829: [2007, 2009]
Sphyraena qenie Klunzinger, 1870: [2008]

Scombridae (1)
Scomber japonicus Houttuyn, 1782: [1992 – WAM 30397.023]

Paralichthyidae (1)
Pseudorhombus cinnamoneus (Temminck & Schlegel, 1846): [2008, 2009]

Bothidae (2)
Asterorhombus intermedius (Bleeker, 1865): [2007]
Bothus pantherinus (Rüppell, 1830): [2008, 2009] (

Soleidae (2)
Dagetichthys marginata (Boulenger, 1900): [2007]
Pardachirus pavoninus (Lacepède, 1802): [1992 – WAM 30397.041, 2008]

Balistidae (6)
Abalistes stellatus (Anonymous, 1798): [2008]
Balistapus undulatus (Park, 1797): [2009]
Balistoides viridescens (Bloch & Schneider, 1801): [1992, 2009]
Melichthys vidua (Richardson, 1845): [1992]
Pseudobalistes flavimarginatus (Rüppell, 1829): [2008]
Sufflamen chrysopterum (Bloch & Schneider, 1801): [1992, 2009]

Monacanthidae (8)
Acreichthys tomentosus (Linnaeus, 1758): [1992 – WAM 30397.011/ 30399.011, 2007]
Aluterus scriptus (Osbeck, 1765): [2008]
Cantherhines pardalis (Rüppell, 1837): [1992, 2008]
Chaetodermis penicilligerus (Cuvier, 1816): [1992]
Pervagor janthinosoma (Bleeker, 1854): [1992, 2009]
Pervagor melanocephalus (Bleeker, 1853): [1992, 2009]
Pervagor nigrolineatus (Herre, 1927): [2007, 2008]
Pseudomonacanthus macrurus (Bleeker, 1856): [1992, 2009]

Ostraciidae (5)
Lactoria cornuta (Linnaeus, 1758): [2008]
Ostracion cubicus Linnaeus, 1758: [1992, 2009]
Ostracion meleagris Shaw, 1796: [1992, 2008]
Ostracion nasus Bloch, 1785: [2008]
Ostracion rhinorhynchos Bleeker, 1851: [1992, 2009]

Tetraodontidae (9)
Arothron hispidus (Linnaeus, 1758): [1992, 2006]
Arothron manilensis (Marion de Procé, 1822): [2006, 2009]
Arothron mappa (Lesson, 1831): [2006, 2009]
Arothron meleagris (Anonymous, 1798): [1992]
Arothron nigropunctatus (Bloch & Schneider, 1801): [1992 – WAM 30403.012, 2009]
Arothron stellatus (Anonymous, 1798): [1992, 2009]
Canthigaster compressa (Marion de Procé, 1822): [2007, 2009]
Canthigaster papua (Bleeker, 1848): [1992, 2008]
Canthigaster valentini (Bleeker, 1853): [2006, 2008]

Diodontidae (3)
Cyclichthys orbicularis (Bloch, 1785): [1992, 2009]
Diodon hystrix Linnaeus, 1758: [1992, 2009]
Diodon liturosus Shaw, 1804: [2006, 2007]

DISCUSSION

Counts

Using regression analysis based on the CFDI, Allen and Adrim (2003) estimate that the entire Indo-Pacific region hosts 3,764 coral reef-associated fish species. TARP plays at least occasional host to 15.2% of them. The same analysis lists the 2,057 coral reef fish species known from across the neighbouring Indonesian archipelago. TARP's five islands in 50 km² of water are 27.9% as speciose as the reef fish assemblage of the 18,000 island-strong, 5,000 km wide Indonesian archipelago. Randall & Lim (2000) have edited a list of all known marine fishes in the South China Sea, from the Taiwan Strait to Singapore. Including pelagic and deep water fishes, the list was 3,365 species long when last compiled. TARP has hosted 17% of all these South China Sea species, whether or not coral reef-associated. Yusuf

et al. (2008) made their own surveys for Tioman island in the far southwest corner of the South China Sea, off the southeast coast of peninsula Malaysia, finding 326 reef-associated fish species. East from Tioman in the South China Sea, and several hundred kilometers closer to TARP, Adrim et al. (2004) have recorded 430 marine fish species in the Anambas and Natuna islands. Just 200 km southwest of TARP, in submerged coral shoals off Brunei totalling about the same area as TARP but 35 km off the coast on average, and in often deeper water, Allen and Erdmann (2012) mention a recently compiled list totalling 672 species. Around 300 km northwest of TARP, lies Layang Layang, the southern-most end of the Spratley island group; an atoll with a large lagoon, rising from a sea bed over a kilometre down. Allen and Erdmann (2012) note that in 2004, Allen identified 459 species there. To the northeast lies the 600 km long Philippine group of islands dominated by Palawan, which also marks the western side of the Sulu Sea, the southern-most islands (part of Sabah) being visible from the northern tip of Borneo, itself some 200 km northeast from TARP. Surveys around Palawan and on the Tubbataha reefs in the centre of the Sulu Sea between 1998 and 2011 (Allen & Erdmann 2012) have identified 1,003 reef-fish species. On the far south eastern side of Sabah, in the northwest corner of the Celebes Sea, lies the Bodgaya and Sipadan islands. After Allen's trip to TARP in 1992, he went on directly to survey their reef fishes, compiling a list of 711, excluding fish market specimens of unknown provenance (unpublished but integrated with his original TARP list from which this paper draws).

The range of predominant fish families found in TARP is broadly similar to the whole Indonesian scene (Allen & Adrim 2003), in which 56% of known species are aggregated in 10 families of which in comparison to TARP, only Scaridae is missing from their list (Muraenidae, Syngnathidae and Lutjanidae are added).

Estimates

The CFDI calculation is problematic for TARP: only 113 (62%) of a combined 181 CFDI species were observed by both Allen and myself; it was not the 27% additive increase from 143 to 181 that might have been seen had TARP's biodiversity simply increased over the 17 years from 1992 to 2009.

One explanatory hypothesis is that TARP is in an unusual location, given its placement on the periphery of the South China Sea, whose broadly circular currents tend to reverse direction twice a year (Hu et al. 2000). Given that pelagic larval dispersal can have variable but significant effects on reef fish persistence (Hogan et al. 2012), this may mean that settled residents in TARP can vary much more than in more enclosed locations where it might be that CFDI calculations are more valid. In this case, it might be more appropriate to apply the higher CFDI regression calculation of (4.234 × CFDI) – 114.446 to data sets collected anywhere along the north Borneo coast or equivalent areas (it is normally reserved for areas of more than 50,000 km^2). If so however, the estimate based solely on Allen's 1992 data would only rise to 491, and for my data set alone, it would only climb to 529. (The estimate based on the combined CFDI would however be 656.)

An alternative hypothesis is that reef fish assemblages change significantly over decadal timescales and a CFDI-related estimate is effectively a point-prevalence estimate. It should not be assumed that a historically complete local reef fish checklist is valid at any given time, nor should a smaller CFDI-related estimate at such a time necessarily indicate a decline in reef fish biodiversity: account should also be taken of the degree of overlap between the lists of CFDI indicator fishes. If there is significant overlap, biodiversity may be changing, but if there is not significant overlap, assemblages may be more stochastic. At the very least, it suggests that CFDI-based calculations should be used cautiously and preferably triangulated against other estimation methods.

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